

DURABLY WETTABLE LIQUID PERVERIOUS WEBS  
PREPARED USING A RADIATION CURING PROCESS

*10 A1*

TECHNICAL FIELD

The present invention relates to a durably wettable, liquid pervious web that is particularly suitable as a topsheet for absorbent articles. More particularly, the invention relates to a polymeric film or nonwoven to which is applied a thin organic material onto at least one surface of the film or nonwoven. The thin organic coating is in the form of a polymer and is obtained by radiation curing of a polymerizable compound, preferably a di-functional acrylate. The invention further relates to a process for making the durably wettable liquid pervious web, and to articles containing the durably wettable, liquid pervious web as a topsheet.

BACKGROUND OF THE INVENTION

Polymeric and nonwoven webs are common components of disposable absorbent articles, dryer sheets and the like. As used herein, the term "web" includes nonwovens and polymeric films. More particularly, macroscopically expanded, three-dimensional, polymeric films have been utilized as topsheet materials for disposable absorbent articles. As used herein, the term "macroscopically expanded", when used to describe three-dimensional webs, refers webs, such as polymeric films, which have been caused to conform to the surface of a three-dimensional forming structure so that both surfaces thereof exhibit the three-dimensional pattern of the forming structure or webs, such as nonwovens, that have an inherent three-dimensional pattern arising from their structure. Regardless of whether the three-dimensional pattern is inherent or generated by application of a forming process, the pattern is readily visible to the naked eye when the perpendicular distance between the viewer's eye and the plane of the web is about 12 inches. By way of contrast, the term "planar", when utilized herein to describe nonwovens and polymeric films, refers to the overall condition of the web when viewed by the naked eye on a macroscopic scale. In this context "planar" webs may include webs having fine-scale surface aberrations on one or both sides, the surface aberrations not being readily visible to the naked eye when the perpendicular distance between the viewer's eye and the plane of the web is about 12 inches or greater.

One macroscopically expanded, three-dimensional apertured polymeric web which is particularly well suited to transferring liquid deposited on one surface thereof to its opposite surface and thereafter isolating the transferred liquid from a wearer's skin is disclosed in commonly assigned U.S. Patent No. 3,929,135 issued to Thompson on Dec. 30, 1975, the

disclosure of which is incorporated by reference herein. Thompson describes a macroscopically expanded, three dimensional web (e.g., a topsheet) comprised of liquid impermeable material, but provided with a pattern of tapered capillaries, the capillaries having a base opening in the plane of the topsheet and an apex opening remote from the plane of the topsheet, the apex opening being in intimate contact with the absorbent pad utilized in the disposable absorbent article. The Thompson topsheet allows the free transfer of liquids from the wearer's body into the absorbent element of the device while inhibiting the reverse flow of these liquids. This provides a relatively much drier surface in contact with the user than had previously been obtainable. Another macroscopically expanded, three-dimensional apertured plastic web well suited for use as a topsheet on absorbent articles such as sanitary napkins is disclosed in commonly assigned U.S. Patent No. 4,342,314 issued to Radel et al. on Aug. 3, 1982, the patent being hereby incorporated by reference herein. The macroscopically expanded, three-dimensional plastic web disclosed in the Radel patent exhibits a fiber-like appearance and tactile impression which has been favorably received by consumers when used as a wearer contacting surface. According to the teachings of the commonly assigned patents to Thompson and to Radel, et al., plastic webs of the aforementioned type can be made by applying a pressure to the web while it is supported on a three-dimensional forming structure until the web is macroscopically expanded to comply with the three-dimensional cross-section of the forming structure on which it is supported. When aperturing of the macroscopically expanded, three-dimensional web is desired, the pressure differential is applied until such time as aperturing of the web in areas coinciding with the apertures in the forming structure has been completed.

A multi-phase, liquid-based process such as that described in U.S. Patent No. 4,609,518, issued September 2, 1986 to Curro et al. (hereafter referred to as "518 patent"), the disclosure of which is incorporated herein by reference, was also developed to provide a film with very small and very large apertures immediately adjacent one another. As the patent discloses, the formation of the very small (including micro-sized) apertures in the direction opposite those formed for large apertures hinders the ability of initially unabsorbed liquid from running off the web's surface. Thus, liquid not immediately transported through the large apertures is restrained from running off the web's surface, and is subsequently taken up through the larger apertures and is deposited in the article's core where the web is used as a topsheet material. These outwardly formed small apertures also reduce the level of web/skin contact and reduce the rigidity of the film, and thereby feel more comfortable to the user. Wearers have reported that such topsheets have a soft silky surface. Alternatively, the '518 patent discloses films where the very small apertures are formed in the same direction as the macro-apertures.

35 Regardless of the means employed for aperture formation, where a wettable film material

is desired, the above references generally obtain such a structure by surface treating the naturally hydrophobic polymeric web with a wetting agent. Surface treatment is generally accomplished by either spraying surfactant onto the web's surface or by dipping the web in a surfactant-containing bath. Regardless of which of these methods is employed, surface treatment suffers from the 5 inability to precisely control the location and level of treatment, as well as adverse effects caused by migration of significant amounts of surfactant into apertures and other components (e.g., absorbent core) when the web is used as a topsheet in an absorbent article. Surface treatment further suffers from the disadvantage that desirable wetting agents, or surfactants, tend to be washed off upon repeated exposure to such liquids. Thus, when used as a topsheet in an absorbent 10 article, the treated webs lose their ability to transport liquid away from the skin and into the article's core after repeated wettings.

U.S. Patent No. 4,535,020, issued to Thomas et al. on August 13, 1985, addresses some of the problems associated with surface treating vacuum-formed apertured films by incorporating hydrophilic surfactant in the polymeric resin before extrusion for film formation (referred to 15 herein as "resin incorporated surfactant", or "RIS"). (See also commonly assigned U.S. Patent Application Serial No. 08/713,377, filed September 13, 1996 by Y. P. Lee, et al.; U.S. Patent No. 4,923,914 to Nohr et al., issued May 8, 1990; U.S. Patent No. 5,057,262 to Nohr et al., issued October 15, 1991; U.S. Patent No. 5,120,888 to Nohr et al., issued June 9, 1992.) According to the teachings of Thomas, after extrusion of the resin/surfactant mixture, and subsequent formation 20 of the apertures, the incompatible surfactant eventually blooms to the film's surface to provide a more durably wettable web. However, as with surface treatment, RIS suffers from some degree of surfactant wash-off during use and/or during manufacture, particularly if liquid pressure differentials are used to form the web's apertures. Also, hydrophilic webs formed using RIS techniques are not immediately wettable and, depending on the relationship between the resin and 25 the surfactant and environmental conditions, may not become wettable for finite periods of time. Similarly, when such webs are used in absorbent articles, there will be some time delay before surfactant (that is washed off during wear) is replenished at the web's surface.

Co-pending U.S. Patent Applications Serial No. 09/157845, filed September 21, 1998 by Y. P. Lee et al. and titled DURABLY WETTABLE, LIQUID PEROUS POLYMERIC 30 WEBS and Serial No. 09/157840, filed September 21, 1998 by P. France et al., titled DURABLY WETTABLE POLYMERIC WEBS PREPARED USING A REMOTE PLASMA POLYMERIZATION PROCESS addressed the need for a durably polymeric web material by disclosing a durable wettable web produced by a plasma induced polymerization processes.

The Lee application discloses a "in-glow" or "direct" plasma polymerization. In this 35 process the web to be treated and the monomers to be reacted are located within the plasma zone

during the polymerization process. While this technique has been found useful for preparing durably wettable webs that are useful as topsheets for absorbent articles, polymerization within the plasma limits, to some degree, the monomers that may be utilized.

The monomer limitations associated with direct plasma polymerization were addressed by 5 the remote plasma polymerization process disclosed in the France application. Remote plasma polymerization is a process in which polymerization is effected in the presence of the plasma, but wherein the web as well as the inlet for the monomer feed are located outside of, or remote from (typically below), the plasma zone. As such, certain desirable monomers for forming the hydrophilic coating can be used in the present process, while they cannot be used where direct 10 plasma polymerization is employed.

Unfortunately, durably wettable webs that are produced by the direct and remote plasma-induced polymerization processes can only be produced in limited amounts as both processes are have web speed limitations. Thus, there remains a need for a durable wettable polymeric web that can be produced by a high speed process with minimal changes in the substrate properties, such as 15 flexibility, texture, comfort, and breathability.

High speed coating processes have been disclosed in related art and in the literature. For example, US Patent No. 4,842,893 and 4,954,371 describe high speed electron beam coating processes for producing coated substrates to be used in monolithic capacitors, magnetic tape and 20 packaging. U.S. Pat. No. 4,842,893 discloses a high speed coating process including flash vaporization system and electron beam curing. Both of these electron beam disclosures are incorporated herein by reference. Other uses of electron beam coatings in the electronic industry field have been reported by Westinghouse Science & Technology Center USA (Adv. Mat. Newsletter Volume 13, No 9, 1991 page 4).

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In summary, while different combinations of surface treatments and processes have been used in the past, there remains the need for a durable wettable polymeric web that can be produced by a high speed process, with minimal changes in the substrate properties, such as flexibility, texture, comfort, and breathability. In short, the present invention fills this need by combining the 30 advantages of a high speed electron beam coating process with the benefits of a durable and hydrophilic coating, to produce an economical durable wettable web for use in absorbent articles.

Accordingly, it is an object of the present invention to provide a liquid pervious polymeric web having improved durable wettability. This durable wettability is attained by applying a electron radiation-induced hydrophilic coating onto at least one surface of a starting

polymeric film, to render the resulting web durably hydrophilic. In particular, the electron radiation-induced coating is attained using an "electron beam" polymerization process.

#### SUMMARY OF THE INVENTION

The present invention relates to a durably wettable polymeric web that is particularly 5 useful as a topsheet material for absorbent articles. In one respect, the invention relates to a durably wettable, liquid pervious web which comprises:

- (i) an apertured web selected from the group consisting of polymeric films or nonwovens; and
- 10 (ii) a substantially continuous hydrophilic coating, less than about 10 microns thick, on at least one surface of the web, wherein said hydrophilic coating is applied to the web by a radiation curing process;

wherein at least one surface of the durably-wettable, liquid pervious web has a Post Aging contact angle that is not more than about 60 degrees greater than the Pre Aging contact angle.

15 In a similar aspect respect, at least one surface of the treated web will have a Post Washing contact angle that is not more than about 60 degrees greater than the Pre Washing contact angle. Preferably, both conditions will exist in a single web.

The invention also relates to an absorbent article comprising a durably wettable, liquid pervious topsheet, the topsheet comprising a web and a hydrophilic coating on at least one surface 20 of the web, wherein the hydrophilic coating is applied to the web by a radiation curing process. In other words, the topsheet of the article comprises the durably wettably, liquid pervious web of the present invention.

Finally, the invention relates to a radiation curing process for making the durably wettable, liquid pervious webs described herein.

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#### DETAILED DESCRIPTION OF THE INVENTION

##### I. Durably Wettable, Liquid Pervious Webs

As discussed in detail below, the present invention relates to a durably wettable, liquid pervious web that is prepared by applying a hydrophilic coating to a starting polymeric film or 30 nonwoven, using a radiation curing process. For purposes of clarity, the term "web" refers to the starting substrates (i.e., a polymeric film or nonwoven) to which the hydrophilic coating is applied. In contrast, the terms "durably wettable, liquid pervious web" or "treated web" refer to

the final product - the film or nonwoven having the durable hydrophilic coating.

As used herein, the terms "hydrophilic" and "wettable" are used interchangeably and refer to surfaces that are wettable by aqueous liquids (e.g., aqueous body liquids) deposited on these surfaces. Hydrophilicity and wettability are typically defined in terms of contact angle and the 5 surface tension of the liquids and solids involved. This is discussed in detail in the American Chemical Society publication entitled Contact Angle, Wettability and Adhesion, edited by Robert F. Gould (Copyright 1964). A web surface is said to be wetted by a liquid (i.e., hydrophilic) when either the contact angle between the liquid and the web surface is less than 90°, or when the liquid tends to spread spontaneously across the surface of the web, both conditions normally co- 10 existing. Conversely, a surface is considered to be hydrophobic if the contact angle is greater than 90° and the liquid does not spread spontaneously across the surface of the web. In general, the lower the contact angle between the surface and the liquid, the more hydrophilic the surface.

The webs of the present invention are "durably wettable", insofar as the hydrophilic character engendered to the otherwise more hydrophobic film is maintained over time and after 15 exposure to liquids. While not being bound by theory, it is believed that typical hydrophilic polymer and surface-treated polymer systems, such as corona discharge treatments, go through a "hydrophobic recovery" process. During the hydrophobic recovery process, surface wettability tends to decay over time because thermodynamics favors the exposure of lower surface energy 20 molecular chain segments at polymer surface. Upon aging, hydrophilic molecular segments reorient and embed themselves and expose hydrophobic segments at polymer surface. If chemical crosslinking is induced at the polymer surface, the crosslinking tends to limit polymer chain mobility, thus significantly slowing the "hydrophobic recovery" process and therefore preserving 25 polymer surface wettability over time. Since Applicants' invention provides for polymer chemical crosslinking, via a radiation curing process, a durably wettable, liquid pervious web can be produced.

As discussed above, prior approaches directed at making hydrophobic films wettable result in initial improvements in wettability, but suffer from low process speeds or the negative attribute that wettability is lost over time and/or upon exposure to liquids. Durable wettability is described herein in terms of the ability of a treated web (as indicated, referred to herein as a 30 durably wettable, liquid pervious to distinguish from the starting "web") to retain its wettable character after aging (referred to as "Post Aging") and/or after exposure to liquids (referred to as "Post Washing"). The methods for measuring Post Aging contact angle and Post Washing contact angle are discussed below.

35 As indicated, the durable wettability of the present webs is attained by use of a radiation

curing process. As used herein, "radiation curing" includes but is not limited to processes wherein monomer curing is accomplished by application of energy such as infra red, electron beam, thermionic or ultraviolet radiation.

5 In one aspect of the present invention, the method of using a high speed vacuum coating process for producing durable and hydrophilic coatings on a web uses at least one movable support such as rotating drum in a vacuum chamber. The surface of the support is maintained at a temperature sufficient to permit condensation of a vaporized curable composition deposited in the chamber. The curable composition is preferably a curable monomer with a relatively low  
10 molecular weight. Monomer vapor is created using a flash vaporizer. The desired amount of curable monomer is metered to a heated flash vaporizer system where the material is vaporized. It is then transported e.g. by its inherent pressure, to the web resting on the rotating drum and condensed on the surface of the web. According to the method, the web is then transported to at least one curing means such as an energy source which emits an electron beam, UV-light  
15 radiation or an electro magnetic field. Alternatively, the curable monomer can also be transferred into radicals by passing through a plasma zone (zone of high voltage discharge). The curing of the monomer by the curing means then provides a durable coating on the web's surface.

20 The apparatus for delivering the curable monomer to the web can use an ultrasonic atomizer that produces micro droplets of curable monomer. The droplets are released into a vaporization tube heated by band heaters. The atomized droplets impinge on the inner wall of the vaporization tube and are instantaneously vaporized, i.e., flash vaporized. This reduces the opportunity for polymerization prior to being deposited on the web.

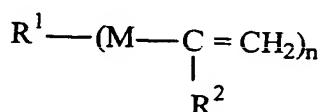
25 The coating formed by the method of the present process has a thickness of less than 10 microns, and preferably less than 2 microns and most preferably in the range of 0.001 to 1 microns. The coatings are formed by depositing at least one vapor of a curable composition, under vacuum, on a movable web which is mounted in thermal contact with at least one support, for continuos processing, preferably a rotating drum, which is maintained at a temperature below the boiling point of the vaporized curable composition under the environmental conditions in the  
30 vacuum chamber. As a result of this temperature differential, the vaporized curable composition condenses on the surface of the web.

35 Curable hydrophilic compositions which may be used to prepare polymeric coatings by the radiation-induced curing process include any hydrophilic composition which can be vaporized and condensed on the web and which comprises at least one component having at least two

olefinic groups per molecule. The components that comprise the curable composition typically are monomeric materials having, on average, about two or more olefinic groups per molecule. For example, a single diolefinic material, mixtures of two diolefins or a mixture of a polyolefin and monolefin may be used. Typically, curable components are relatively low in molecular weight, 5 between 150 and 1000 grams per mole, and preferably in the range 200 to 300 grams per mole. The curable component or component mixtures employed have a vapor pressure such that they condense on at least one surface of the web. For example, such vapor pressures are pressures between about  $1 \times 10^{-6}$  Torr and  $1 \times 10^{-1}$  Torr, most preferably a vapor pressure of approximately  $1.33 \times 10^{-2}$  mbar at standard temperature and pressure, (i.e., relatively low boiling materials) are 10 selected.

Polyfunctional acrylates are particularly useful as they have low molecular weights, high reactivities and form cured films with the desired hydrophilic properties.

The general formula for a preferred polyfunctional acrylate is:



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wherein:

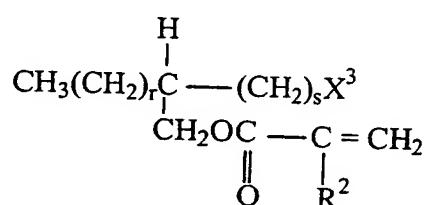
M may be a chemical functional group selected from chemical linkages including ester, ether, amine, and amide;

20 R1 may be an aliphatic, alicyclic or mixed aliphatic-alicyclic radical derived from a compound of the formula R1(OH)<sub>m</sub>, wherein m is 2 or more;

R2 may be an alkyl segment with carbon number no greater than 5 (e.g. hydrogen, methyl, ethyl, propyl, butyl or pentyl) or a modified alkyl segment with backbone carbon number no greater than 5 comprising at least one polar functional group selected from chemical classes including alcohol, amine, acid and amide; and

25 n is from 2 to 4.

Polyfunctional acrylates may also be used in combination with various monoacrylates, such as those having the formula:



wherein:

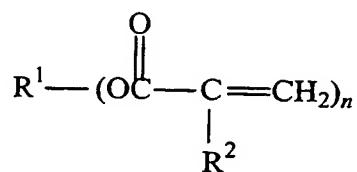
R2 is defined above;

r and s are each 7 or 8 and the sum of r and s is 15 ;and

5 X<sup>3</sup> is CN, COOR<sup>3</sup>, CNHR<sup>3</sup>, and CONHR<sup>3</sup> wherein R<sup>3</sup> is hydrogen or an alkyl radical containing 1-4 carbon atoms.

The preferred form of polyfunctional monomer is when M is an ester group, which forms a diacrylate having general formula:

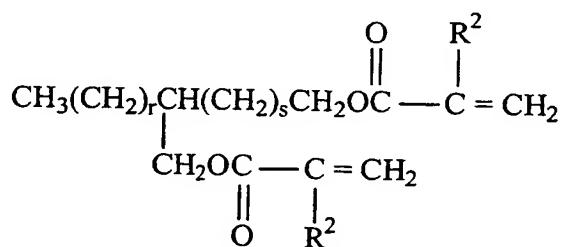
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An even more preferred monomer structure is when the above diacrylate is combined with a

15 monoacrylate wherein X<sup>3</sup> is COOCH<sub>3</sub>.

Diacrylates of the formula below are particularly preferred:



20 wherein:

r and s are each 7 or 8 and the sum of r and s is 15.

These high-vapor-pressure monomers can be flash vaporized already at low temperatures and thus are not degraded (cracked) or polymerized by the heating process. The absence or low amount of 25 unreactive degradation products results in coatings with a reduced levels of volatile components in which substantially all of the deposited monomer is reactive and will cure to form an integral film when exposed to a source of radiation. These properties make it possible to provide a

substantially continuous coating despite the fact that the deposited film is very thin. The cured films typically exhibit excellent adhesion and are resistant to chemical attack by organic solvents and inorganic salts.

5 With respect to the starting web, the web may be flat (two dimensional) or complex (three dimensional, including previously apertured films) prior to being subjected to the radiation curing process. That is, radiation curing may be conducted either before or after formation of the apertures in a film or nonwoven. In a preferred embodiment, the radiation curing process will be conducted after aperture formation, so as to better preserve a uniform hydrophilic coating on the  
10 film's surface.

Polymeric films to be coated via the radiation curing process will be derived from thermoplastic polymers. In general, the term "thermoplastic polymer" is used herein to mean any thermoplastic polymer which can be used for the preparation of films. Examples of thermoplastic polymers include, by way of illustration only, end-capped polyacetals, such as  
15 poly(oxymethylene) or polyformaldehyde, poly(trichloroacetaldehyde), poly(n-valeraldehyde), poly(acetaldehyde), poly(propionaldehyde), and the like; acrylic polymers, such as polyacrylamide, poly(acrylic acid), poly(methacrylic acid), poly(ethyl acrylate), poly(methyl methacrylate), and the like; fluorocarbon polymers, such as poly(tetrafluoroethylene), perfluorinated ethylene-propylene copolymers, ethylene-tetrafluoroethylene copolymers,  
20 poly(chlorotrifluoroethylene), ethylene-chlorotrifluoroethylene copolymers, poly(vinylidene fluoride), poly(vinyl fluoride), and the like; polyamides, such as poly(6-aminocaproic acid) or poly( $\epsilon$ -caprolactam), poly(hexamethylene adipamide), poly(hexamethylene sebacamide), poly(11-aminoundecanoic acid), and the like; polyaramides, such as poly(imino-1,3-phenyleneiminoisophthaloyl) or poly(m-phenylene isophthalamide), and the like; polyarylenes,  
25 such as poly-p-xylylene, poly(chloro-p-xylylene), and the like; polyaryl ethers, such as poly(oxy-2,6-dimethyl-1,4-phenylene) or poly(p-phenylene oxide), and the like; polyaryl sulfones, such as poly(oxy-1,4-phenylenesulfonyl-1,4-phenyleneoxy-1,4-phenylene-isopropylidene-1,4-phenylene), poly-(sulfonyl-1,4-phenyleneoxy-1,4-phenylene-sulfonyl-4,4'-biphenylene), and the like; polycarbonates, such as poly(bisphenol A) or poly(carbonyldioxy-1,4-phenylene-isopropylidene-1,4-phenylene), and the like; polyesters, such as poly(ethylene terephthalate),  
30 poly(tetramethylene terephthalate), poly(cyclohexylene-1,4-dimethylene terephthalate) or poly(oxymethylene-1,4-cyclohexyl-enemethyleneoxyterephthaloyl), and the like; polyaryl sulfides, such as poly(p-phenylene sulfide) or poly(thio-1,4-phenylene), and the like; polyimides, such as poly(pyromellitimido-1,4-phenylene), and the like; polyolefins, such as polyethylene,

5 polypropylene, poly(1-butene), poly(2-butene), poly(1-pentene), poly(2-pentene), poly(3-methyl-1-pentene), poly(4-methyl-1-pentene), 1,2-poly-1,3-butadiene, 1,4-poly-1,3-butadiene, polyisoprene, polychloroprene, polyacrylonitrile, poly(vinyl acetate), poly(vinylidene chloride), polystyrene, and the like; copolymers of the foregoing, such as acrylonitrile-butadiene-styrene (ABS) copolymers, and the like.

Preferred polymers are polyolefins and polyesters, with polyolefins being more preferred. Even more preferred are those polyolefins which contain only hydrogen and carbon atoms and which are prepared by the addition polymerization of one or more unsaturated monomers. Examples of such polyolefins include, among others, polyethylene, polypropylene, poly(1-butene), poly(2-butene), poly(1-pentene), poly(2-pentene), poly(3-methyl-1-pentene), poly(4-methyl-1-pentene), 1,2-poly-1,3-butadiene, 1,4-poly-1,3-butadiene, polyisoprene, and the like. In addition, such term is meant to include blends of two or more polyolefins and random and block copolymers prepared from two or more different unsaturated monomers. Because of their commercial importance, the most preferred polyolefins are polyethylene and polypropylene.

15 In addition to polymeric films, webs that can be used to produce the durably wettable, liquid pervious webs of the present invention include but are not limited to spun bonded, hydroentangled, needled and polymericly bound nonwovens. Suitable nonwoven webs are typically formed from organic textile fibers including but not limited to cotton, wool, wood, jute, viscous rayon, nylon, polyester, polyolefins, carbon, or mixtures thereof. Inorganic fibers such as 20 glass and metal can be used alone or in combination or further combined with organic fibers. In the case of staple fibers, fiber length varies from about 1/4 inch to about 2 or more inches. In the case of spun bonded webs, the fiber lengths are indefinite. The staple fibers used in hydroentangled, needled and polymericly bound nonwovens are processed through conventional textile machinery.

25 For example, in producing a polymericly bound nonwoven web, a carding machine may be used to form a continuous length of rather two-dimensional loosely associated fibers known as a carded web. These webs may be assembled to form a multiple layer or three-dimensional fibrous web of significant weight, e.g., from about several grams to thousands of grams per yard. In continuous nonwoven fibrous webs, the textile fibers are arrayed at various angles to the 30 lengthwise axis of the web. When a web is formed by the action of a carding machine, the fibers are usually predominantly oriented in the machine direction and, on the other hand, isotropic webs may be formed such as by air-laying. The fibrous webs described above are typically impregnated with a polymeric binding agent (polymericly bound). In a preferred form, the polymeric binders are applied as emulsions of acrylic, polyvinylacetate, or similar polymeric

nature, and mixtures thereof. Preferably, the fibers are unwoven and substantially haphazardly oriented and adhesively bonded together with polymeric binder.

Hydroentangled and needled webs are distinct from polymericly bound webs as they rely principally on the physical entanglement of their fibers to provide web integrity. In contrast to 5 polymericly bound and physically entangled webs, spun bond webs typically are composed of fibers of infinite length that are bound together through solvent or melt processes.

Typically, and preferably, before monomer is deposited on a web, an initial step is performed. The purpose of this step is to clean the web's surface to promote adhesion of the subsequently deposited thin hydrophilic coating. Cleaning may be accomplished by subjecting 10 the web's surface to radiation (herein referred to as radiation cleaning) from an energy source including but not limited to, infra red, electron beam, thermionic or ultra violet radiation or by plasma cleaning. Apparatuses that are suitable as energy sources in the present invention are disclosed in U.S. Patent No. 4,842,893 issued to Yializis on Apr. 29, 1988, the disclosure of which is incorporated by reference herein. In the radiation cleaning embodiment, the radiation 15 source is preferably a gas discharge electron beam gun. The gun directs a flow of electrons through a emitter window onto the web's surface, thereby abstracting atoms or breaking bonds, thus creating free radicals. These free radicals are unstable and seek to satisfy a more stable state thus they serve as bonding sites for the monomers that are used to produce the web's hydrophilic coating. Cleaning is controlled by matching the electron beam voltage to the dielectric thickness 20 or depth of cleaning that is desired. For example, a 10 Kv electron voltage will penetrate to a film depth of about 1 micron..

Suitable plasma systems for use in the present invention incorporate a parallel plate electrode design where materials to be treated are exposed to the primary field of RF energy, but are not part of the circuitry. With higher pressure processes (but still within the general definition 25 of a cold gas plasma), some form of gas delivery system, designed to create a uniform laminar flow of process gas throughout the entire chamber volume is beneficial. In multiple electrode/shelf designs, it is important that each of the electrodes receive equal amounts of RF energy. In this manner a uniform glow discharge is created between each shelf or in each plasma zone. Solid state components and microprocessor control of the system parameters of process 30 time, flow rate, power level, and working pressure, will also ensure process uniformity, efficiency, and repeatability.

Since plasmas are electrically conductive atmospheres, they carry a characteristic impedance to the output of the RF generator. Therefore, the preferred plasma process utilizes a matching network to constantly tune the plasma impedance to the output impedance of the RF

generator. Advanced plasma systems suitable for use in the present invention are available from HIMONT Plasma Science, Foster City, Calif. (a business unit of HIMONT U.S.A., Inc.), and incorporate an automatic matching type of network and provisions for error checking during the process.

5 During the initial cleaning step, process gases are typically either Ar alone, O<sub>2</sub> alone, or mixtures (e.g., 1:1) of Ar and O<sub>2</sub>. Gas flow rates are typically in the range of 20-100 sccm (standard cc/min), preferably 40-80 sccm, and most preferably 50-60 sccm. RF power is approximately 1100 watts, and process pressure is about 0.04 Torr. However, it should be appreciated that treatment pressure, time and power are interrelated, rather than independent, 10 variables. The effect of the level selected for each of these variables will determine the extent of web surface modification; also related are the chamber volume and geometry as well as the sample size and surface geometry. The selection of the level for these variables is well within the ordinary skill of practitioners in the art to which this invention pertains. After the optional cleaning step, the next step is the radiation curing process, as described above and in more detail 15 in the examples below.

The process according to the present invention can continuously create web surfaces having coatings that are durable and that increase the surface energy of the web to render a durably wettable, liquid pervious web. The coating is durable, in that it is maintained over time, 20 even after exposure to water or other aqueous liquids. In this regard, the webs of the present invention are described in one respect in terms of their ability to remain wettable over time and/or after exposure to liquids. The ability to remain wettable over time is assessed by measuring the treated web's Post Aging contact angle. This measurement involves storing the treated web at 60° C for 16 hours, to artificially age the sample, before measuring contact angle. The ability to 25 remain wettable after exposure to liquids is assessed by measuring the treated web's Post Washing contact angle. This measurement involves placing a 2 in. x 2 in. web sample in a 250 ml water bath at 65° C for 90 sec with vigorous agitation prior to measuring contact angle. Procedures and devices for measuring contact angle between a liquid and a web surface are well known in the art. However, water contact angle, measured with a goniometer (Model # 100-00, 30 Rame-Hart, Inc., Mountain Lakes, NJ), is used to assess the web wettability of the present invention. All contact angle measurements are reported as the average measurements on 3 samples.

In one aspect, the treated web of the present invention will have a Post Aging contact angle that is not more than about 60 degrees greater than the web's Pre Aging contact angle (i.e.,

the contact angle as measured before storage at 74°C for 16 hours). Preferably, the treated web will have a Post Aging contact angle that is not more than about 40 degrees, more preferably not more than about 20 degrees, still more preferably not more than about 10 degrees, greater than the Pre Aging contact angle. In another respect, the treated web of the present invention will have a 5 Post Washing contact angle that is not more than about 60 degrees greater than the treated web's Pre Washing contact angle (i.e., the contact angle as measured before the treated web is placed in a 250 ml water bath at 65° C for 90 sec with vigorous agitation). In this regard, the treated web will preferably have a Post Washing contact angle that is not more than about 40 degrees, more preferably not more than about 20 degrees, still more preferably not more than about 10 degrees, 10 greater than the Pre Washing contact angle. In a preferred aspect, the treated web of the present invention will exhibit both the Post Aging and Post Washing requirements discussed above.

The durably wettable, liquid pervious webs of the present invention will exhibit either (preferably both) a Post Aging or a Post Washing contact angle of less than about 90 degree, preferably not more than about 70 degree, more preferably not more than about 50 degree, still 15 more preferably not more than about 30 degree, and most preferably not more than about 20 degrees.

## II. Absorbent Articles

As used herein, the term "absorbent article" refers generally to devices used to absorb and 20 contain body exudates, and more specifically refers to devices which are placed against or in proximity to the body of the wearer to absorb and contain the various exudates discharged from the body. The term "absorbent article" is intended to include diapers, catamenial pads, tampons, sanitary napkins, incontinent pads, training pants and the like, as well as wipes, bandages and wound dressings. The term "disposable" is used herein to describe absorbent articles which are 25 not intended to be laundered or otherwise restored or reused as an absorbent article (i.e., they are intended to be discarded after limited use, and, preferably, to be recycled, composted or otherwise disposed of in an environmentally compatible manner). A "unitary" absorbent article refers to absorbent articles which are formed as a single structure or as separate parts united together to form a coordinated entity so that they do not require separate manipulative parts such as a separate 30 holder and pad.

It is to be understood that the overall size, shape, and/or configuration of the absorbent article, if any, into which the treated webs according to the present invention are incorporated, or utilized in conjunction with, have no criticality or functional relationship to the principles of the present invention. Such parameters, however, must be considered along with the intended liquid

and intended functionality when determining appropriate treated web configurations.

In addition to the treated webs of the present invention, absorbent articles will also comprise an absorbent core for retention of any absorbed body liquids. Exemplary absorbent structures for use as the absorbent core in the present invention are described in U.S. Patent No. 5 4950,264 issued to Osborn on August 21, 1990; U.S. Patent No. 4,610,678 issued to Weisman et al. on September 9, 1986; U.S. Patent No. 4,834,735 issued to Alemany et al. on May 30, 1989; European Patent Application No. 0 198 683, the Procter & Gamble Company, published October 22, 1986 in the name of Duenk et al.; U.S. Patent No. 4,673,402 issued to Weisman et al. on June 16, 1987; and U.S. Patent No. 4,888,231 issued to Angstadt on December 19, 1989. The absorbent core may further comprise the dual core system containing an acquisition/distribution core of chemically stiffened fibers positioned over an absorbent storage core as detailed in U.S. Patent No. 5,234,423, entitled "Absorbent Article With Elastic Waist Feature and Enhanced Absorbency" issued to Alemany et al., on August 10, 1993; and in U.S. Patent No. 5,147,345, entitled "High Efficiency Absorbent Articles For Incontinence Management" issued to Young, LaVon and Taylor on September 15, 1992. The disclosure of all of these patents is incorporated herein by reference.

A preferred embodiment of a unitary disposable absorbent article made in accordance herewith is a catamenial pad, or sanitary napkin. As used herein, the term "sanitary napkin" refers to an absorbent article which is worn by females adjacent to the pudendal region, generally external to the urogenital region, and which is intended to absorb and contain menstrual liquids and other vaginal discharges from the wearer's body (e.g., blood, menses, and urine). Interlabial devices which reside partially within and partially external to the wearer's vestibule are also within the scope of this invention. Suitable feminine hygiene articles are disclosed in U.S. Patent No. 4,556,146, issued to Swanson et al. on Dec. 3, 1985, U.S. Patent No. 4,589,876, issued to Van Tilberg on April 27, 1993, U.S. Patent No. 4,687,478, issued to Van Tilburg on Aug. 18, 1987, U.S. Patent No. 4,950,264, issued to Osborn, III on Aug. 21, 1990, U.S. Patent No. 5,009,653, issued to Osborn, III on April 23, 1991, U.S. Patent No. 5,267,992, issued to Van Tilburg on Dec. 7, 1993, U.S. Patent No. 5,389,094, issued to Lavash et al. on Feb. 14, 1995, U.S. Patent No. 5,413,568, issued to Roach et al. on May 9, 1995, U.S. Patent No. 5,460,623, issued to Emenaker et al. on Oct. 24, 1995, U.S. Patent No. 5,489,283, issued to Van Tilburg on Feb. 6, 1996, U.S. Patent No. 5,569,231, issued to Emenaker et al. on Oct. 29, 1996, and U.S. Patent No. 5,620,430, issued to Bamber on April 15, 1997, the disclosure of each of which is incorporated by reference herein.

In a preferred embodiment of the present invention, the sanitary napkin has two flaps each of which are adjacent to and extend laterally from the side edge of the absorbent core. The flaps

are configured to drape over the edges of the wearer's panties in the crotch region so that the flaps are disposed between the edges of the wearer's panties and the thighs. The flaps serve at least two purposes. First, the flaps help serve to prevent soiling of the wearer's body and panties by menstrual liquid, preferably by forming a double wall barrier along the edges of the panty.

5 Second, the flaps are preferably provided with attachment means on their garment surface so that the flaps can be folded back under the panty and attached to the garment facing side of the panty. In this way, the flaps serve to keep the sanitary napkin properly positioned in the panty. The flaps can be constructed of various materials including materials similar to the topsheet, backsheet, tissue, or combination of these materials. Further, the flaps may be a separate element attached to

10 the main body of the napkin or can comprise extensions of the topsheet and backsheet (i.e., unitary). A number of sanitary napkins having flaps suitable or adaptable for use with the sanitary napkins of the present invention are disclosed in U.S. Patent No. 4,687,478 entitled "Shaped Sanitary Napkin With Flaps", which issued to Van Tilburg on August 18, 1987; and U.S. Patent No. 4,589,876 entitled "Sanitary Napkin", which issued to Van Tilburg on May 20, 1986. The

15 disclosure of each of these patents is hereby incorporated herein by reference.

In a preferred embodiment of the present invention, an acquisition layer(s) may be positioned between the topsheet and the absorbent core. The acquisition layer may serve several functions including improving wicking of exudates over and into the absorbent core. There are several reasons why the improved wicking of exudates is important, including providing a more even distribution of the exudates throughout the absorbent core and allowing the sanitary napkin to be made relatively thin. The wicking referred to herein may encompass the transportation of liquids in one, two or all directions (i.e., in the x-y plane and/or in the z-direction). The acquisition layer may be comprised of several different materials including nonwoven or woven webs of synthetic fibers including polyester, polypropylene, or polyethylene; natural fibers including cotton or cellulose; blends of such fibers; or any equivalent materials or combinations of materials. Examples of sanitary napkins having an acquisition layer and a topsheet are more fully described in U.S. Patent No. 4,950,264 issued to Osborn and U.S. Patent Application Serial No. 07/810,774, "Absorbent Article Having Fused Layers", filed December 17, 1991 in the names of Cree, et al. The disclosures of each of these references are hereby incorporated herein by reference. In a preferred embodiment, the acquisition layer may be joined with the topsheet by any of the conventional means for joining webs together, most preferably by fusion bonds as is more fully described in the referenced Cree application.

Catamenial pads may be constructed as follows. Onto silicone-coated release paper a spiral pattern of H2031 Findlay hot melt adhesive is applied at 0.04 g/in<sup>2</sup>. This adhesive layer is

transferred onto the top (wearer-facing) side of a secondary topsheet by rolling the secondary topsheet and coated release paper together with a hand roller. The secondary topsheet is formed of a nonwoven material known as Fort James Airlaid Tissue, Grade 817, commercially available from the Fort James Corp. of Green Bay, Wisconsin. A topsheet of the present invention is applied to the adhesive side of the secondary topsheet and the two are bonded by gently pressing them together with a hand roller. Two strips of one-quarter-inch double-sided tape are applied along both long edges of a polyethylene backsheet. The absorbent core is added to construct the complete absorbent structure.

As used herein, the term "diaper" refers to a garment generally worn by infants and 10 incontinent persons that is worn about the lower torso of the wearer. It should be understood, however, that the present invention is also applicable to other absorbent articles such as incontinent briefs, incontinent pads, training pants, diaper inserts, facial tissues, paper towels, and the like. In general, a diaper of the present invention will comprise a liquid pervious topsheet of 15 the present invention; a liquid impervious backsheets joined with the topsheet; and an absorbent core positioned between the topsheet and the backsheets. Additional structural features such as elastic members and fastening means for securing the diaper in place upon a wearer (such as tape tab fasteners) may also be included.

While the topsheet, the backsheets, and the absorbent core can be assembled in a variety of well known configurations, a preferred diaper configuration is described generally in U.S. Patent 20 No. 3,860,003 (Buell), issued January 14, 1975, the disclosure of which is incorporated by reference. Alternatively, preferred configurations for disposable diapers herein are also disclosed in U.S. Patent No. 4,808,178 (Aziz et al.), issued February 28, 1989; U.S. Patent No. 4,695,278 (Lawson), issued September 22, 1987; and U.S. Patent No. 4,816,025 (Foreman), issued March 28, 1989, the disclosures of each of these patents hereby being incorporated herein by reference. 25 Suitable incontinence articles for adult wearers are disclosed in U.S. Patent No. 4,253,461 issued to Strickland, et al. on March 3, 1981; U.S. Patent Nos. 4,597,760 and 4,597,761 issued to Buell; U.S. Patent No. 4,704,115; U.S. Patent No. 4,909,802 issued to Ahr, et al.; U.S. Patent No. 4,964,860 issued to Gipson, et al. on October 23, 1990; and in U.S. Patent Application Serial No. 07/637,090 filed by Noel, et al. on January 3, 1991 (PCT Publication No. WO 92/11830 30 published on July 23, 1992). The disclosure of each of these references is incorporated herein.

The absorbent core of the diaper is positioned between the topsheet and the backsheets. The absorbent core can be manufactured in a wide variety of sizes and shapes (e.g., rectangular, hourglass, asymmetrical, etc.). The total absorbent capacity of the absorbent core should, however, be compatible with the design liquid loading for the intended use of the absorbent article 35 or diaper. Further, the size and absorbent capacity of the absorbent core can vary to accommodate

wearers ranging from infants through adults.

As indicated, the absorbent core may include a liquid distribution member. In a preferred configuration, the absorbent core preferably further includes an acquisition layer or member in liquid communication with the liquid distribution member and located between the liquid distribution member and the topsheet. The acquisition layer or member may be comprised of several different materials including nonwoven or woven webs of synthetic fibers including polyester, polypropylene, or polyethylene, natural fibers including cotton or cellulose, blends of such fibers, or any equivalent materials or combinations of materials.

In a preferred embodiment, the diaper will comprise elasticized leg cuffs. The elasticized leg cuffs can be constructed in a number of different configurations, including those described in U.S. Patent No. 3,860,003; U.S. Patent No. 4,909,803, issued to Aziz et al. on Mar. 20, 1990; U.S. Patent No. 4,695,278, issued to Lawson on Sep. 22, 1987; and U.S. Patent No. 4,795,454, issued to Dragoo on Jan. 3, 1989, each being incorporated herein by reference.

In use, the diaper is applied to a wearer by positioning the back waistband region under the wearer's back, and drawing the remainder of the diaper between the wearer's legs so that the front waistband region is positioned across the front of the wearer. The tape-tab or other fasteners are then secured preferably to outwardly facing areas of the diaper.

### III. Example:

The following example is illustrative and is not meant as a limitation of the invention disclosed and claimed herein.

A web coating run is carried out in a 16" diameter vacuum drum manufactured by Leybold. The electron-beam gun is a rod-fed, 10 kw, single position, beam source (Airco Temescal Model RIH-270). This gun has water-cooled deflection coils with flush magnetic poles, a deflected beam for increased filament life, a water-cooled copper hearth, and rod feeding to the source. It employs a six-turn, 0.030-in.-diameter, tungsten filament and produces an arrow head spot (generally triangular) 3/16 to 1/4 in. long, depending on the filament-to-beam-former spacing and on the size of the orifice in the wall. The power supply is a constant voltage, 30-kw unit. The power output provides dc voltage at a constant 10 kv at a total maximum electron beam current of 3 amp. Using this supply, one 30 kw or three 10 kw guns may be operated independently of each other, in the same vacuum chamber. A vacuum-discharge pressure range is in the system is  $5 \times 10^{-4}$  torr on the electron beam gun side and  $150 \times 10^{-3}$  torr on the discharge side. An ion gage is used to measure the vacuum, and a Pirani gage is used to measure the discharge pressure. At the start of the run,

the chamber is evacuated below  $1 \times 10^{-2}$  torr. A apertured polyethylene film is fed into the machine at a webspeed of 600 feet/min and methacrylic acid is flash evaporarized (275 degrees C) onto the film at a flow rate of 150 sccm. The coated film is then treated with the e-beam source operating at 10 kw electron beam source power, 2000 volts on the substrate 6.5 inches from the 5 source. The resulting durably-wettable, liquid pervious web has at least one surface that is hydrophilic and that has a Post Aging contact angle that is not more than about 60 degrees greater than the Pre Aging contact angle and a Post Washing contact angle that is not more than about 60 degrees greater than the Pre Washing contact angle.